Hybrid CFD/CAA Modeling for Liftoff Acoustic Predictions

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This paper presents development efforts at the NASA Marshall Space flight Center to establish a hybrid Computational Fluid Dynamics and Computational Aero-Acoustics (CFD/CAA) simulation system for launch vehicle liftoff acoustics environment analysis. Acoustic prediction engineering tools based on empirical jet acoustic strength and directivity models or scaled historical measurements are of limited value in efforts to proactively design and optimize launch vehicles and launch facility configurations for liftoff acoustics. CFD based modeling approaches are now able to capture the important details of vehicle specific plume flow environment, identify the noise generation sources, and allow assessment of the influence of launch pad geometric details and sound mitigation measures such as water injection. However, CFD methodologies are numerically too dissipative to accurately capture the propagation of the acoustic waves in the large CFD models. The hybrid CFD/CAA approach combines the high-fidelity CFD analysis capable of identifying the acoustic sources with a fast and efficient Boundary Element Method (BEM) that accurately propagates the acoustic field from the source locations. The BEM approach was chosen for its ability to properly account for reflections and scattering of acoustic waves from launch pad structures. The paper will present an overview of the technology components of the CFD/CAA framework and discuss plans for demonstration and validation against test data.